



California's 2001 Emission Inventory

A Review and Look to the Future

July 2001

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California Environmental Protection Agency

Air Resources Board

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Introduction

The California Air Resources Board (ARB or Board) maintains and updates a statewide emission inventory, which provides a strong technical foundation for the Board's air pollution control programs. This report provides an overview of the inventory, recent improvements, and uses of the specialized inventories derived from the ARB's comprehensive emission inventory system. The 2001 emission inventory is being presented to the Board as part of the triennial review process established in State law. However, as a practical matter, specialized inventories are frequently approved as part of the Board's action on individual regulations and attainment plans required by the federal Clean Air Act and the California Clean Air Act. The triennial reviews represent a "snapshot" of the overall statewide emission inventory at a particular point in time. Improvements are made on an ongoing basis.

The statewide inventory estimates emissions from virtually all sources of air pollution in California. The core inventory is presented as an "annual average." This allows a general comparison of the relative contribution of various emission sources such as cars, trucks, refineries, and power plants. However, the timing and location of emissions plays an important role in determining the impacts of emissions on compliance with health-based air quality standards. For these purposes, the statewide inventory is refined for individual regions and seasons on a pollutant specific basis. For ozone attainment plans (i.e., federal State Implementation Plans or "SIPs" or State clean air plans), a summer season inventory is needed. For particulate matter, multiple seasonal inventories may be needed depending on the nature of the problem(s) in the region.

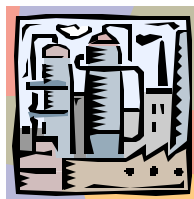
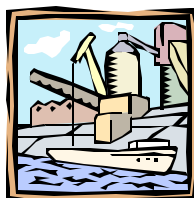
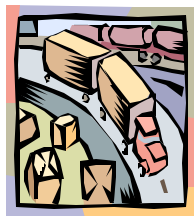
This report summarizes the statewide inventory for "criteria" pollutants, as well as those pollutants that form criteria pollutants, but does not include toxic air contaminants. The key pollutants included in this report are reactive organic gases (ROG), oxides of nitrogen (NO_x), oxides of sulfur (SO_x), particulate matter (PM₁₀), and carbon monoxide (CO). The criteria pollutant inventory focuses on the pollutants that

contribute to the formation of ozone (ROG and NO_x) and secondary particulate matter (NO_x , SO_x , ROG), as well as directly emitted particulate matter. These inventories are essential since most regions in California exceed state air quality standards for ozone and PM_{10} .

The statewide inventory also includes total organic gases (TOG) and total particulate matter (PM). The inventory of TOG includes "reactive" and relatively "non-reactive" components. As mentioned previously, emissions of ROG are a concern from an ozone formation standpoint. The non-reactive portion of TOG, primarily methane, is of concern in terms of climate change. The PM inventory includes emissions of particles larger than PM_{10} , which like other inventoried pollutants, contribute to poor visibility.

The detailed statewide inventory is presented in a separate document – "California's 2001 Emission Inventory". The inventory is broken out by county in about 70 individual subcategories of emissions. These cover on-road motor vehicles (such as cars, trucks, buses, motorcycles), other mobile sources (such as trains, aircraft, ships, farm and construction equipment), stationary sources (industrial and commercial facilities), and area-wide sources (such as consumer products, pesticides, and paints).

Major revisions to the motor vehicle inventory were approved by the Board in May 2000. This year's revisions to the inventory are relatively minor and result in lower ROG, CO, and PM_{10} emissions and essentially no change in NO_x emission estimates relative to EMFAC2000-based inventory estimates. These changes are the combined result of updated travel activity and control strategies, as well as staff's most recent technical improvements to the emission rates and methodologies that comprise the EMFAC model itself. Updates to several off-road mobile categories were approved by the Board in January 2000. The Board has approved other inventory improvements in conjunction with regulatory actions taken since the last triennial update. These previous changes and the recreational marine engine inventory published on June 8, 2001 with a proposed regulation, have been incorporated in the proposed 2001 statewide inventory.



The emission inventory includes emission estimates for hundreds of source categories.

It is important to note that we are not seeking approval of the revised inventories for the purpose of federal transportation conformity. When an area revises its SIP, the region includes a vehicle emission inventory based on the available EMFAC model and other data. Once new transportation conformity emission budgets based on this SIP are approved, the region then uses the same EMFAC model, together with the latest vehicle activity and control strategy information, to assess conformity with those budgets.

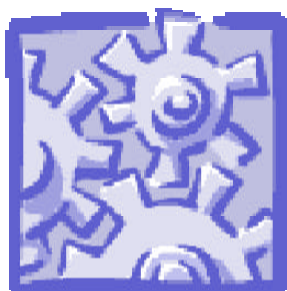
In fact, we do not intend to submit any EMFAC model revisions to the U.S. Environmental Protection Agency until the federal conformity process is clearly defined administratively to allow technical updates without triggering a SIP revision. We believe this is entirely consistent with Clean Air Act requirements.

Why Do We Need Emission Inventories?

Emission inventories provide an important foundation for improving air quality and public health. Emission inventories tell us what quantities of various pollutants are being emitted to the air, where they are being emitted, who is emitting them, and when they are being emitted. The federal Clean Air Act requires specialized emission inventories for State Implementation Plans (SIPs) and transportation planning and conformity purposes. State law also requires inventories under the California Clean Air Act and for air toxics risk assessment.

We use emissions data to develop control measures that improve California's air quality as we work to attain federal and state health-based air quality standards and to reduce air toxics exposures. Emission inventory information supports numerous ARB programs including diesel particulate measures, emission reduction strategies for motor vehicles, other mobile sources, fuels and consumer products, as well as neighborhood level assessments. Emission inventories are also inputs to air quality modeling used on a regional basis to develop State clean air plans and federal SIPs.

Emission inventories are the foundation for improving air quality and public health.



The ARB develops a number of distinct inventories for specialized purposes.

In addition to the statewide annual average inventory, we produce a number of other inventories for specialized purposes. For example, seasonally adjustable inventories are needed based on the pollutant of concern. Inventories used for assessing SIP compliance and transportation conformity analyses have to meet specific legal requirements and are maintained independently of the statewide annual average. In addition, we prepare future year inventories, which reflect both the continuing downwind trend in air emissions in California, as well as giving us a starting point for determining the additional emission reductions needed to meet health-based air quality standards.

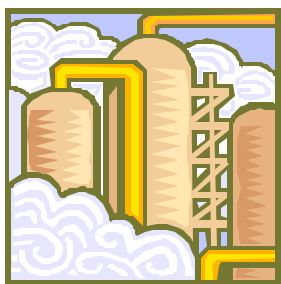
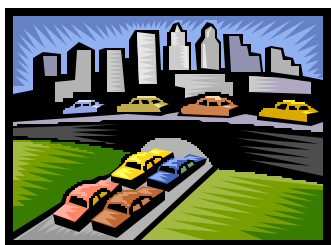
Sources and Types of Emissions

To help better understand the factors that cause poor air quality, we quantify the sources of emissions that are all around us. To make the task more manageable, we subdivide the sources of emissions into five major subcategories that include on-road mobile sources, other-mobile sources, stationary sources, area-wide sources, and natural sources.

Emissions from motor vehicles and off-road mobile equipment are categorized as either "on-road" or "other mobile." The on-road category includes passenger cars and trucks, heavy-duty trucks, buses, and motorcycles. The other-mobile category includes off-road recreational vehicles, lawn and garden equipment, farm and construction equipment, planes, trains, boats, and ships.

Stationary sources include industrial and commercial facilities such as refineries, power plants, manufacturing operations, gas stations, and dry cleaners. Generally, emissions estimates from stationary sources are reported directly to air districts, which then transmit the information to the ARB.

Emissions from man-made sources other than vehicles or individual facilities are considered "area-wide." Examples are consumer products such as hairspray, household cleaners, pesticides, and paints. Other



area-wide sources are fugitive dust from roads and construction operations, and agricultural burning.

Finally, the inventory also includes emissions from natural sources such as wildfires, windblown dust from natural lands, and natural oil seeps. Biogenic emissions from trees and other vegetation are not included in the “annual average” inventory because their emissions are strongly dependent on temperature and other environmental variables and therefore vary widely from day to day and season to season. However, we do develop day-specific biogenic emissions estimates for use in clean air plans and SIPs.

Summary of 2001 Statewide Emissions

Table 1 summarizes California's 2001 statewide emissions inventory for the most significant of the criteria pollutants produced by anthropogenic (man-made) sources. This single table represents the compilation of about 70 specific source categories, information from over 17,000 individual facilities, incorporation of growth factors, and the benefits of ARB and individual air district control measures. Emission factors for many source categories reported in this inventory reflect the results of ARB's comprehensive emission testing and research programs.

For those criteria pollutants of greatest significance for ARB programs (ROG, NO_x, and PM₁₀), the pie charts in Figure 1 show the relative contribution of each major anthropogenic source category in California. These pie charts show statewide emissions as the average number of tons emitted for a typical day during the 2001 calendar year. The relative contribution of these categories changes over time as control strategies are implemented.

The statewide inventory is developed using information from over 17,000 individual facilities.

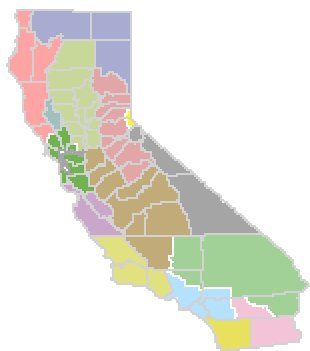


Table 1. Statewide 2001 Annual Average Emission Inventory*
(tons/day)

Emissions Source	ROG	CO	NO _x	SO _x	PM ₁₀ **
Mobile					
On-Road	1,200	11,835	1,826	12	57
Other-Mobile	429	2,974	986	150	70
Stationary	645	357	583	138	140
Area-Wide	<u>754</u>	<u>2,295</u>	<u>94</u>	<u>5</u>	<u>2,079</u>
Totals[^]	3,028	17,461	3,489	305	2,346

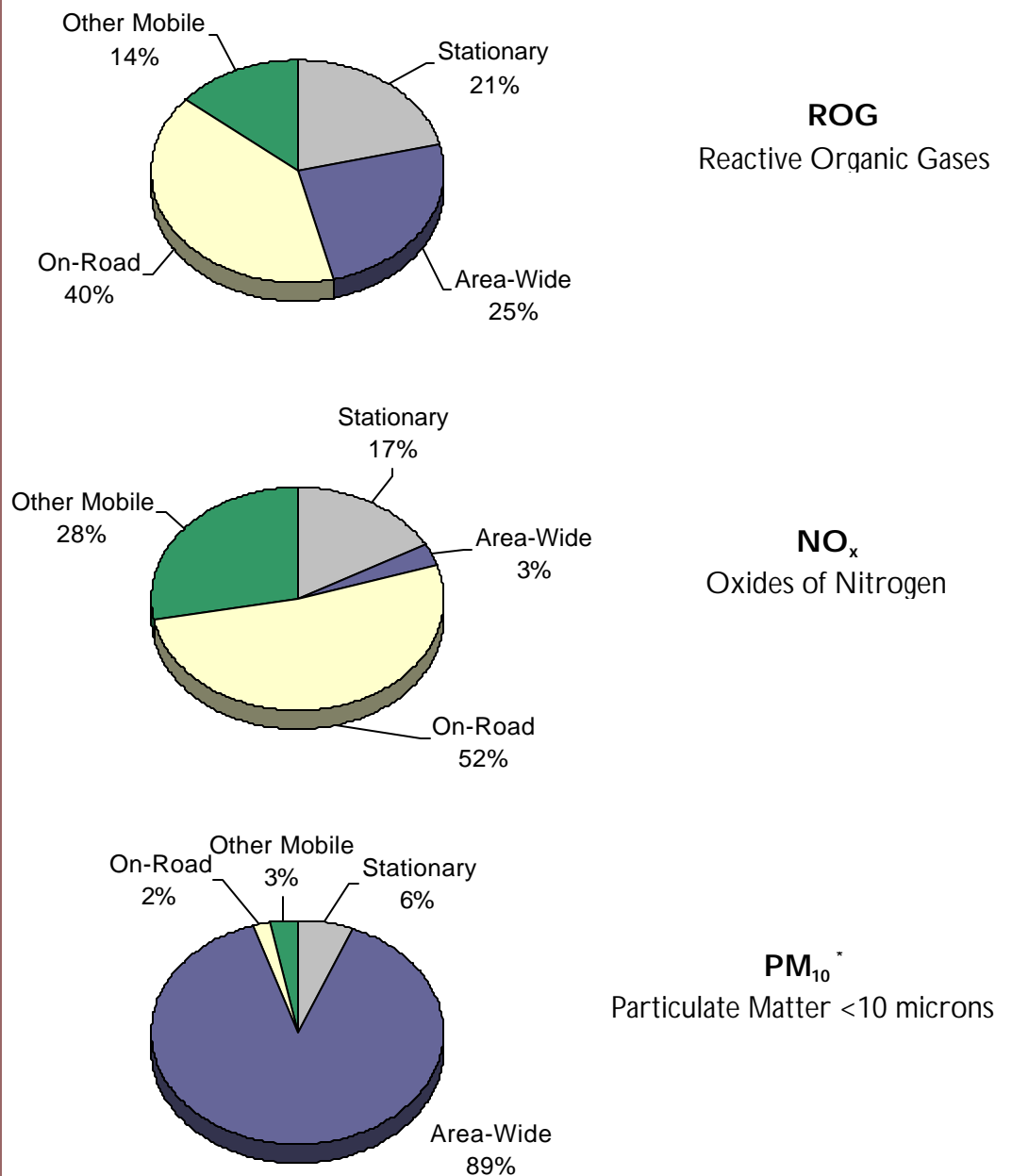
* Includes only anthropogenic sources.

** Includes only directly emitted particles.

[^] May not add due to rounding. Does not include approximately 800 tons/day of wind blown dust emissions from Owens and Mono Lakes exposed lake beds.

More detailed emission inventory information by county and air basin, as well as source category, is provided in the 2001 emission inventory report, "California's 2001 Emission Inventory," that can be downloaded from our web site at <http://www.arb.ca.gov/emisinv/sb2174.htm>. Hard copies of the report may be obtained by calling the ARB's Public Information Office at (916) 322-2990. This inventory will be the basis for developing the final 2001 emission inventory that will be published in the ARB publication, "The 2002 California Almanac of Emissions & Air Quality," in January 2002. The Almanac will also include historical trends and forecasts of criteria air pollutants, as well as information on toxic air contaminants.

Figure 1. Statewide Annual Average Emission Contributions by Source Category for 2001



* Directly emitted PM₁₀ only. Does not include emissions that form "secondary" PM₁₀.

Recent Emission Inventory Improvements

Improved Emission Estimates

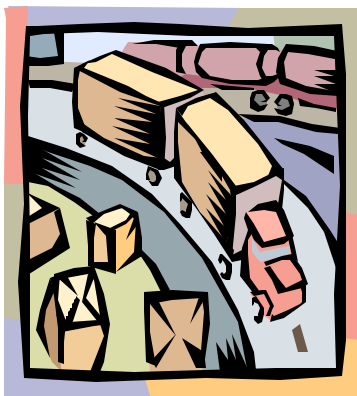
The 2001 emission inventory presented in this report reflects a number of improvements since the last triennial report. A summary of some of these enhancements is provided below.

General

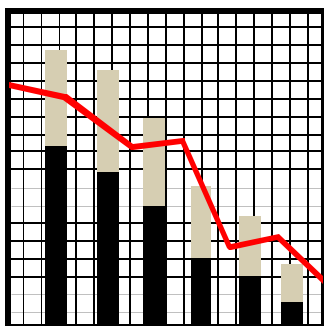
- Year 2001 emissions are available via our web site. These estimates reflect our most recent inventory methodologies.

Mobile Sources

- In May 2000, ARB's on-road vehicle inventory was updated and approved by the Board.
- Staff has incorporated technical improvements on driving cycles, emission factors, vehicle age distribution, running loss emission estimates, and heavy duty truck data into the EMFAC2001 model to better represent real world driving conditions.
- The proposed inventory includes updates made by local transportation and planning agencies to vehicle activity and growth projections. In addition, this inventory reflects changes to the vehicle control strategy.
- In January 2000, the Board approved changes as to how ARB's OFFROAD model estimates emissions from large diesel engines used in off-road applications.
- The consolidated OFFROAD model estimates emissions for thirteen equipment classes and allows these off-road emissions to be spatially allocated using improved statewide spatial surrogates. This is a tremendous improvement to the piecemeal approach used previously.



EMFAC is the ARB's on-road vehicle emission inventory model.



The ARB has developed a sophisticated forecast model to estimate future emission levels.

Stationary Sources

- Working closely with the air districts over the past year, ARB has streamlined and standardized the stationary source inventory data acquisition process.

Forecasting Emissions

- What will the air quality be like in ten years? In twenty years? To design effective new clean air strategies, we need to project future emissions with existing requirements and anticipated growth. This is an essential first step in developing plans to meet air quality standards by the required deadlines. ARB's computer model for forecasting emissions called the California Emissions Forecasting System, helps us answer these questions. The model is updated on an ongoing basis as new control strategies are adopted and growth estimates are revised.

Community Health

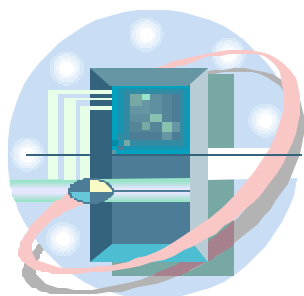
- Statewide and regional emission inventories tell us a lot about emissions at the community level. However, even more detailed emission inventories will help address people's questions about emission levels in their particular neighborhood. As part of our community health program, we are doing more comprehensive assessments of the emissions sources in a few neighborhoods in conjunction with neighborhood air monitoring. The combination of these efforts is designed to improve our understanding of people's air pollution exposures at the community level. We hope that these pilot projects will help improve our ability to do community assessments on a wider scale.

Particulate Matter Emissions

- Virtually all regions in California continue to exceed the State standard for PM_{10} . Most urban areas are also exceeding the new federal $PM_{2.5}$ or "fine particle" standards. Due to the complexity of California's PM_{10} problem (which includes $PM_{2.5}$ as a subset), emission inventory improvements are broad in scope. Secondary formation of PM_{10} and $PM_{2.5}$ involves NO_x , SO_x , ammonia, and ROG emissions. Directly emitted particles include particulates from diesel engines, as well as particles of dust and smoke.

Biogenics

- Naturally occurring emissions from vegetation or "biogenic" emissions can contribute to both ozone and particulate matter formation. Plants also reduce air pollution through uptake and physical deposition. To understand how to best improve the air, we include biogenic ROG emissions in our air quality models. These emissions are estimated using a California-specific biogenic emissions model developed by the ARB.



The emission inventory is more user friendly and more highly automated.

Improved Inventory Features

During the past year, we have tried to improve the overall functionality and user friendliness of the emission inventory. Some of these changes include:

- A wider range of ARB emission inventory data are now available via the Internet. Standardized and some custom reports can be run directly by the user.
- Updates to emissions data can be submitted electronically by air districts, facilities, and ARB staff.

Proposed Changes for Board Approval

Of the many improvements that have been made to the emission inventory, we ask that the Board approve two changes. As described below, these are updates to the statewide on-road vehicle inventory and refinements in our estimates of emissions from marine pleasure craft.



Numerous improvements have been made to the ARB's on-road emission inventory.

On-Road Vehicle Inventory

EMFAC2000 was presented to the Board in May 2000. At that time the inventory was tentatively approved with a directive from the Board to make certain adjustments to the inventory. We are now requesting Board Approval of the adjusted on-road vehicle inventory, the first in a series of annual updates to this inventory. As discussed previously, we are not seeking approval of the revised inventories for the purpose of federal transportation conformity.

The proposed modifications to the inventory are based on the elements listed below and were presented to the public in workshops held in both northern and southern California in May of this year.

Control Strategy

- Incorporation of the most recently adopted emissions standards, including modifications to the LEVII program, adoption and alignment with the federal Tier II program, revised rules for heavy-duty diesels (2007), and new emission standards for heavy-duty gas vehicles (2001).
- Incorporation of current Inspection and Maintenance (I/M) program status.

Vehicle Activity

- Incorporation of the latest activity information from councils of government (COGs) and metropolitan planning organizations (MPOs).
- Updated out-of-state diesel vehicle travel estimates.

EMFAC2001 Model

- Modification to the air conditioning methodology.
- Updated emission factors for light-duty diesel vehicles, heavy-duty diesel idle emission rates, and Mexican vehicles.
- Updated estimates of the number of unregistered vehicles.

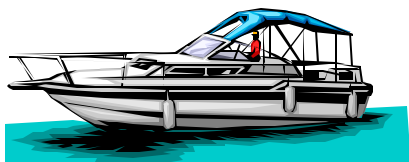
Table 2 shows the proposed modifications to the statewide inventory decreased our estimate of emissions of ROG, CO, and PM₁₀ from on-road vehicles by ten percent, six percent and four percent, respectively, and resulted in no significant change in NO_x emissions in the year 2001.

Table 2. Statewide On-Road Emissions Inventory for Year 2001 (Tons per Day)

Method	ROG	CO	NO _x	PM ₁₀
EMFAC2000 Method	1,332	12,596	1,822	60
EMFAC2001 Method	1,200	11,835	1,826	57
% Difference	-9.9%	-6.0%	0.2%	-4.1%

Marine Engines

Unlike the on-road mobile source inventory that is periodically brought before the Board for approval in its entirety, the off-road inventory is presented to the Board by major source category in conjunction with a proposed regulation. The last off-road category to be reviewed and approved by the Board was large compression ignited engines greater than 25 horsepower, presented in January 2000. We are currently seeking approval of the revised inventory of recreational marine engines, in support of a proposed regulation for inboard and sterndrive marine engines.



We have modified both the emission rates and activity estimates underlying the inventory for this category of engines. The proposed statewide, annual average, 2001 estimates for this category are 134, 687, 23, and 8 tons per day of ROG, CO, NO_x, and PM₁₀, respectively. This estimate was developed using activity and emission rate data consistent with those presented in the regulatory staff report entitled "Public Hearing to Consider Adoption of Emission Standards and Test Procedures for New 2003 and Later Spark-Ignited Inboard and Sterndrive Marine Engines" that was mailed on June 8, 2001, 45 days prior to this hearing. Controls that are being proposed in the upcoming regulation are not included in the baseline estimates presented here.

Checking Our Work – Inventory Verification



Several verification methods show that the EMFAC model provides reasonable emission estimates.

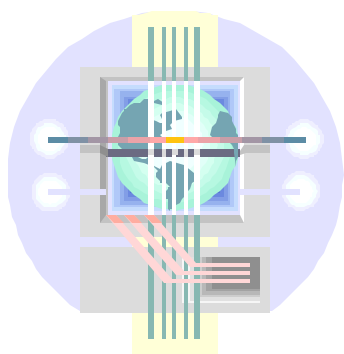
Although we believe that the 2001 emission inventory is significantly improved over previous inventories, we recognize the importance of verifying our emissions estimates. Ideally, we would like to verify the accuracy of all the emission sources, including on-road mobile, other-mobile, stationary, and area-wide. However, most of the verification methods developed so far are applicable only to the on-road mobile source emission inventory. Four of the techniques we used to verify the accuracy of the proposed on-road vehicle inventory are: tunnel studies, fuel consumption estimates, fuel-based inventories, and comparison with independent data sets.

A number of tunnel studies have been performed in California since 1987. Emissions from vehicle fleets traveling through those tunnels are compared to output for similar fleets calculated using various versions of the EMFAC model. Fuel consumption studies have compared the amount of fuel estimated by the EMFAC model to be consumed by a fleet of vehicles to actual fuel sales for that fleet reported by the State Board of Equalization. Fuel-based inventory studies have compared emissions derived from total fuel sales and remote sensing data to EMFAC emissions estimates. Finally, emissions from an independent data set of representative vehicles have been compared to output from the EMFAC model.

It should be noted that each of these verification methods has its own inherent bias and limitations, and should therefore not be viewed as an absolute benchmark against which the accuracy of the EMFAC2001-based inventory is judged. Rather, results from all of these verification methods need to be assessed in their entirety and the weight of evidence considered. Given the uncertainties in all of these verification methods, results are best viewed in aggregate and as a means of

quantifying relative improvements in the on-road emission inventory over time.

Results of these verification method comparisons show differences from the inventory ranging from less than one percent to approximately forty percent, depending upon the method and pollutant being compared. For most verification methods and pollutants, emissions are within twenty percent of the proposed inventory with no consistent bias towards either over- or underestimation. Given that the uncertainty in most of these verification methods is probably at least twenty percent, this level of agreement supports the continued use of the EMFAC model. Finally, for those verification methods that have been compared to various versions of the EMFAC model, there is better agreement with newer versions of the model, indicating that mobile source emission inventory improvements made to date have been steps in the right direction.



Emission Inventory Improvements for the Next Year

For the remainder of 2001 and through 2002, the key concepts driving our inventory improvement efforts are accuracy and accessibility. Our 2001-2002 projects focus on providing more accurate data, more easily and more completely. We are also targeting our efforts to those areas that are most critical to new emission reduction strategies. Some of the projects for meeting these goals include the following:

- Most of the work done by the ARB has a spatial component. Air pollution happens 'someplace'. However, most of our emission estimation data do not include an easily usable spatial component. We are continuing to incorporate geographic information system (GIS) technology into our way of doing business so as to 'spatially-enable' the emission inventory. This is allowing us to better visualize, analyze, and maintain the information and tools we generate.

- Several of our databases and reporting schemes lack across-the-board consistency. For example, emissions reported for toxics for a single facility might not use the same device and stack identifiers when reporting their criteria pollutants. We are working with air districts to improve consistency and information access.
- People want help interpreting emission data. We are currently developing the Community Health Air Pollution Information System, a web-based tool that will make it possible to map where facilities are located throughout California and examine what pollutants they emit.
- We all want to know if we may be living next to sources of airborne toxic emissions. We are developing a comprehensive, up-to-date, statewide toxics emission inventory, based on reported criteria pollutants and speciation profiles to supplement known toxics emission estimates. These data, as well as health risk modeling data, at the individual facility, county, and statewide level will be available on the ARB web site in December 2001.
- For dispersed sources of emissions such as unpaved road dust, prescribed burning, or off-road equipment, we are developing models that can provide emissions output as maps for viewing, gridded data for risk or air quality modeling, or as the traditional tabular data. We are incorporating this emissions modeling approach for ammonia, wildfires and prescribed burning, agricultural burning, and some mobile sources.



The emission inventory will utilize GIS (geographic information system) based methods and web-based interfaces. This approach provides flexibility and power.

More Maps of Emissions, More Detail

We are improving our emission mapping capability by using GIS. Although useful, our current maps of emissions are simplistic. The underlying road maps are not very detailed, which makes finding specific locations difficult. In addition, there is not a good display of

schools, hospitals, or other sensitive sites. During the next year, with the incorporation of GIS, we are adding these capabilities, in addition to mapping the emissions from cars, trucks, gas stations, consumer products, and other sources.

With these improvements to our web-based maps, it will be much easier to see the full picture of pollutants emitted to the air.

Ultimately, the maps will allow display of the emissions from a variety of sources at whatever level is desired, be it the state, a county, or a specific neighborhood.

Evaluating Neighborhood Air Pollution

We are improving our estimates of neighborhood level emissions. Only three years ago, technology limitations made this type of effort unrealistic, so we focused on regional or citywide emissions. It was not feasible to focus down to a single community or city block. Now the mapping tools are available and our biggest challenge is collecting detailed source specific emission data.



We are now developing tools that give us the capability to develop and display what are called “micro-scale” emission inventories. For these inventories, every potential commercial site of emissions is included. Ultimately, all of this information, including individual facility emissions, car and truck emissions, household products such as paints, and more can be displayed on emission maps.

Conclusions - The Vision, The Future

We have discussed what has been done over the past year to make emission inventories better, what we are doing this year, and now, the future. The current California emission inventory estimates are generated by a complex system of various models, methods, and data from a number of agencies. To make using the data more useful, we are developing a new approach for our emission estimation systems that uses a GIS-based design to tie together and analyze previously independent and separate inventories.

For example, future emission estimates for cars and trucks will be based on traffic estimates for individual road segments and neighborhoods rather than regional averages. Emissions from some large facilities may be measured and reported continuously in real time. Emissions for wildfires will be estimated based on satellite images, or site-measured global positioning data, which provide fire perimeters. Our ammonia emissions model will incorporate environmental data such as soil types, temperature, and humidity.

The goal is to fully integrate 'geo-spatial' data into our emission inventory work. With this approach, virtually all data has a specific geographic location associated with it. The concept is relatively simple – everything that produces emissions is assigned a location on a map. Applying this approach on a statewide basis to many tens of thousands of diverse air emission sources is a significant challenge.

More Information for More People

Our primary goal is to provide user-friendly access to emission inventory data that is visual, comprehensible, accurate, and informative. We want to make it easier for anyone to evaluate the sources, quantities, and types of air pollution for a neighborhood, a county, a region, or even statewide. Providing extensive access to inventory data through the Internet will help us meet this goal. As our current web



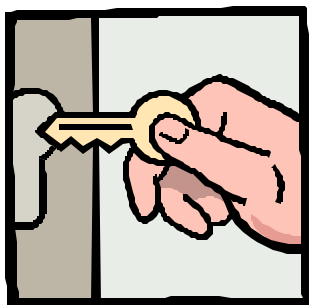
*Inventory information
is available at our website:
www.arb.ca.gov/emisinv/eib.htm.*

site shows (<http://www.arb.ca.gov/emisinv/eib.htm>), we now have a large amount of inventory information already available on the web. However, there is much more to do. Currently, information can be difficult to locate, much of the information is only available as numerical tables, and the analysis capabilities are limited. We are working to improve this site and make it more complete and useful.

New Opportunities and Tools

Our improved emission inventory will provide many new tools to help better understand air quality. A few of the new capabilities that will result from these efforts include:

- Inventory consolidation – Inventory data will be easier to find and use.
- Neighborhood and community analysis – Tools are being developed to help people evaluate air emissions at a small-scale, neighborhood level and to assist with investigating exposures to toxic air pollutants.
- Show who is doing what – You will be able to easily generate customized maps and graphs showing which sources of air pollution are the most important for a community or regional area.
- Ask questions – Want to evaluate the effects of adding or decreasing emissions? Is a new company moving into your neighborhood? See how it compares to what is around you now. Evaluate the effects of new emissions controls, population growth, or other factors using new “what-if” and query tools.
- New inventory structure – More consistent, current, and easier access to emissions data will be available by incorporating an overall GIS-based inventory structure.
- Health risks – What are the cumulative estimated air-related health risks of multiple facilities and pollution sources? Maps and tools are being developed to provide the answers.



The new California Emission Inventory System will unlock the ARB's emission inventory information and make it more accessible.

- Ambient air quality – Emissions estimates are helpful, but what do air monitors show? Improvements to the inventory systems will include links that will provide easy and seamless access to the ambient air quality data to help answer this question. We also plan to provide maps and tools that make it easier to identify the sources of pollution in areas with poor air quality.

If you would like additional information regarding the emission inventory, improvements to the inventory, and specific improvement projects, check our web site: <http://www.arb.ca.gov/emisinv/eib.htm>. To contact us, our email address is: eibweb@arb.ca.gov or you can write us at the address shown below.

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Staff Recommendation

The staff recommends the Board approve the statewide, annual average, 2001 emission inventory, including the recreational marine engine emission inventory.



The California Air Resources Board is a part of the California Environmental Protection Agency.

The Mission of the California Air Resources Board is:

"To promote and protect public health, welfare, and ecological resources through the effective and efficient reduction of air pollutants while recognizing and considering the effects on the economy of the state."